SAMS-CR-12-02-77

# SPACE TRANSPORTATION SYSTEM THREAT [redacted]

NOVEMBER 1977

This report was prepared under the direction of the Director of Intelligence, Space and Missile Systems Organization, for the Space Transportation System (STS) Program. The Threat has been developed from approved DOD intelligence products with such extrapolations as have been necessary to cover the extended time period of concern and those threat aspects unique to the STS. Contributions and validation comments from the U.S. Air Force, the National Security Agency and the Defense Intelligence Agency have been included.



[redacted]

SAMS-CR-12-02-77
November 77

DEFENSE INTELLIGENCE AGENCY
WASHINGTON, D.C. 20301

21 FEB 1978

U-8632/DT-4

TO: Assistant Chief of Staff, Intelligence
Department of the Air Force
ATTN: INA
Washington, D.C. 20330

SUBJECT: Threat Assessment Report - Space Transportation System (STS)

1. DIA in consultation with NSA validated the current and projected threats to STS presented in subject document to be as correct and consistent as currently available intelligence and reasonable technological projections permit. This validation is provided within the scope of DIA's responsibilities as defined by DoD Directives 5105.21 and C-4600.3.

2. The threat presented in subject document has been explicitly tailored to STS. It is valid only for purposes of the STS December 1977 DSARC review. It must be updated and revalidated prior to its use for any subsequent DSARC review.

FOR THE DIRECTOR:

Jack Vorona

JACK VORONA
Deputy Director for Scientific
and Technical Intelligence

# PREFACE

[redacted] The Space Transportation System (STS) Threat Assessment Report was prepared under the guidance of the ad hoc STS Threat Steering Group. The group was convened to assist in the preparation and validation of a total threat package for the STS, to comply with DOD Directives 5105.21, 5000.1, 5000.2, C-4600.3 and C-3100.9. As executive service for the Interim Upper Stage development, the Air Force was responsible for preparing the threat report, with contributions and consultation from appropriate services and agencies, including the Central Intelligence Agency. The group was chaired by LtCol Harold W. Gale, AFSC/INA. Membership consisted of representatives from DIA, NSA, and USAF. The Air Force Systems Command Space and Missile Systems Organization (SAMSO/IN) prepared the report, with contributions from the Steering Group services and agencies. All-source levels of information were considered. Review and validation were accomplished simultaneously and jointly by the responsible DOD agencies. No minority reports were submitted. The threat report was prepared and validated in accordance with the applicable DOD directives.

DIA, in consultation with the National Security Agency, has participated in an advisory role throughout the generation of the threat information contained in this document. A special effort has been made in this assessment to maintain consistency with other recently DIA validated threat assessments, especially in the longer term projections. The report is made under DOD 5105.21 to support DSARC reviews and is valid for the Milestone II scheduled for the IUS Program in December 1977. This assessment must be updated and a new validation performed prior to any further DSARC review. Validation does not extend to vulnerability related comments designated in the text by inclusion in brackets as [ X X X ].

TABLE OF CONTENTS [redacted]

# I. Space Transportation System (STS) Threat [redacted]

## A. Introduction [redacted]

[redacted] Threats against the Shuttle Orbiter, Interim Upper Stage (IUS), Tracking and Data Relay Satellite System (TDRSS), and related ground facilities were considered. [The threat to the Titan 34D/IUS configuration will not exceed that defined against the Orbiter/IUS configuration.] Until completion of initial engine burn, threats to the IUS will be the same as those against the Orbiter. Each threat was analyzed to determine its technical feasibility, probability of development and the likely impact on the system.

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[redacted] This document projects threats against the STS in three separate time frames: existing (1977), near term (to 1985) and far term (to 2000). Existing threats are those threats considered effective in 1977. Near Term threats are those that will be effective by the year 1985. Far Term threats include those that may be effective by the year 2000. Threats which may be employed against the STS are also projected into six levels of conflict as follows:

1. [redacted] Peace - No significant armed conflicts occurring anywhere in the world.

2. [redacted] Crisis - A significant armed conflict is ongoing but the U. S. is not directly involved. This level includes such conflicts as the Arab-Israeli wars. Also included are confrontations between the United States-Soviet/Chinese and their allies which may involve U. S. forces in an active but less than combat role. Examples are the several Berlin incidents, the Cuban missile crisis and the Pueblo incident.

3. [redacted] Non-Nuclear Theater War - A conflict that involves U. S. and USSR forces or interests on an active basis and that excludes CONUS,

Alaska/Hawaii and U. S. territories. The U. S. forces may be involved in either a supportive or combat role. Non-nuclear battles at sea and in space are consigned to this level.

4. [redacted] Nuclear Theater War - Same as above except that nuclear weapons are involved.

5. [redacted] Controlled Strategic Exchange - U. S. Zone of the Interior is at risk. This level includes limited counterforce and/or limited countervalue exchanges. The objective of such exchanges would be to enforce certain demands or to extract certain concessions while avoiding general nuclear war.

6. [redacted] General Nuclear War - All systems and geographical areas are at risk. This level includes massive exchanges involving both pre-planned actions and various degrees of battle control.

(U) Threats are given a probability of occurrence at different levels of conflict. The following five levels of likelihood are used in this document:

| Description of Likelihood | Probability (%) |
|---|---|
| Very High | 90 - 99 |
| High | 60 - 90 |
| Moderate | 40 - 60 |
| Low | 10 - 40 |
| Very Low | 1 - 10 |

B. Summary [redacted]

[redacted] The summary highlights those Soviet systems that pose the most significant threats or have a high probability of developing into significant threats to the STS. The threat projections are based primarily on technical capability and an estimate of Soviet intent.



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# II. SPACE TRANSPORTATION SYSTEM DESCRIPTION [redacted]

## A. GENERAL [redacted]

[redacted] The Space Transportation System (STS) is composed of the Space Shuttle Vehicle (SSV), an Interim Upper Stage (IUS), the ground systems needed to launch, operate and maintain the STS and the elements of command, control and communications necessary for effective mission management (including TDRSS). The STS may place satellite vehicles in a low earth orbit or, when required, deploy a satellite with an interim upper stage propulsion system which would place the satellite into its final orbit. In addition to placing satellite vehicles into orbit, the STS can retrieve payloads from earth orbit and return them to earth or permit them to be serviced in space. In the Spacelab configuration, the shuttle can act as host for a variety of observable platform, test beds and experimental laboratories. (References 1 - 6 apply to this section).

## B. SPACE SHUTTLE FLIGHT SYSTEM [redacted]

[redacted] The Space Shuttle Flight System consists of an Orbiter, an External Tank and two Solid-Rocket Motors which comprise a Solid Rocket Booster. The Orbiter and Solid-Rocket Booster are reusable elements whereas an External Tank is expended on each launch. The Orbiter main rocket engines, used during ascent, obtain their propellants from the External Tank. Smaller Orbiter rocket engines provide orbital insertion, maneuvering and control, and reentry capabilities during space flight, utilizing propellants carried on board the Orbiter. The Solid Rocket Booster burns in parallel with the Orbiter Main Propulsion System and is separated from the Orbiter External Tank at approximately 45.7 km. The Solid-Rocket Motors descend on parachutes and impact in the ocean about 280 km downrange. They are retrieved by ships and returned to land where they are refurbished and then reused on subsequent flights.

Before injection the External Tank separates and falls ballistically into a little used area of the Indian or South Pacific Ocean depending on the launch site. The Orbiter alone then continues its ascent to a low earth orbit into which the payload is deployed. The Orbiter is designed to carry a variety of payloads, attached or free-flying, which may include the IUS intended to carry payloads into orbits higher than those attainable by the Orbiter alone. When an IUS-equipped satellite system is deployed from the Orbiter, the Air Force Satellite Control Facility becomes the active controller of the IUS for all flights and the active controller of IUS and payloads for DOD flights. The Satellite Test Center (STC) activates

the IUS transponders, attitude control systems, and initiates the sequence of burns necessary to move the payloads to their final orbits.

After the payload or IUS/payload is deployed and checked out, the Orbiter will continue other assigned functions and/or initiate its deorbit maneuvers and return to the landing site.

## C. GROUND SUPPORT SYSTEMS [redacted]

[redacted] The Space Shuttle Vehicle (SSV) and payloads will be launched from two launch and landing sites, one at NASA Kennedy Space Center (KSC) at Cape Canaveral, Florida, the other at Vandenberg AFB (VAFB), California. The ground support systems at KSC and VAFB are similar but have significant differences necessitated by mission, policy and geographical variations.

At KSC, the SSV is processed in an Integrate-Transfer-Launch mode, in which the various elements of the vehicle (Orbiter, Solid Rocket Booster, External Tank) are mated and checked out in the Vehicle Assembly Building onto a Mobile Launch Platform which transfers the integrated SSV to the Launch Pad. In a normal processing flow, the Orbiter returns from a mission to the Landing Facility (runway), guided by a Microwave Scanning Beam Landing System. Ground Support Equipment provides needed cooling, power, etc. to the Orbiter as it is towed to the Orbiter Processing Facility where the flight crew exits, and the Orbiter is safed, deserviced as necessary and checked out. Periodic and unscheduled maintenance is performed and the Orbiter is readied for the next launch. Returned payloads are removed in the Orbiter Processing Facility, and some payloads, especially the Space Lab, are installed. The Orbiter is then towed to the Vehicle Assembly Building, where it is ready to be mated to the rest of the SSV. The solid rocket motor segments arrive at KSC by rail, are checked out in a refurbishment and processing facility, then are assembled with other recovered components and parachutes into a Solid Rocket Booster in the Vehicle Assembly Building. The External Tank arrives at KSC by sea-going barge, is checked out, and then mated to the two Solid Rocket Motors on the Mobile Launch Platform. After the Orbiter is mated to the Solid Rocket Booster and External Tank, the integrated SSV is checked out and then transferred on the Mobile Launch Platform to the Launch Pad, where it has final launch preparations. Most DOD payloads are installed at the launch pad through the Payload Changeout Room. The vehicle is then serviced, the crew enters, and the countdown proceeds through launch. After launch, the Solid Rocket Motors are retrieved at sea and towed to Cape Canaveral AFS, where they are disassembled and cleaned. The used motor segments are

shipped back to the manufacturer for refurbishment. Some components, including the parachutes, are refurbished at KSC. The cycle then begins again with the Orbiter landing.

At VAFB, processing of the SSV is similar to KSC but follows an Integrate-on-Pad method in which the elements of the SSV are mated and checked out on the launch pad itself. After landing, the Orbiter is towed first to the Safing and Deservicing Facility, where the Orbiter ordnance is safed and the fluid systems deserviced to safe levels. The Orbiter is then towed to the Orbiter Maintenance and Checkout Facility to complete its processing as in the Orbiter Processing Facility at KSC. When ready, the Orbiter is transported to the Launch Pad to be mated to the rest of the vehicle. Solid Rocket Booster processing at VAFB is similar to that at KSC except that the Booster is assembled and checked out on the Launch Pad. The External Tank arrives at VAFB by barge, is checked out, and mated to the Solid Rocket Booster on the pad. The Orbiter is mated to the Solid Rocket Booster and External Tank on the pad and the integrated SSV checked out. Payloads are checked out and installed at the Launch Pad using the Payload Preparation Room and Payload Changeout Room. The countdown and launch proceed as at KSC. Solid Rocket Motors launched from VAFB are recovered at sea and towed to Port Hueneme Naval Base, where they are disassembled and refurbished at the motor contractor facility.

In addition to differences in SSV processing, KSC and VAFB differ in payload processing. At KSC, NASA payloads will be assembled at the Spacecraft Assembly and Encapsulation Facility, then transported to the Payload Changeout Room at the Launch Pad. The Interim Upper Stage (IUS) is assembled in the Solid Motor Assembly Building, then transferred to the Spacecraft Assembly and Encapsulation Facility for NASA payloads or to the Launch Pad for DOD payloads. DOD spacecraft will be assembled and checked out at the Satellite Assembly Building, then transported to the pad for integration. At VAFB, STS payload handling is on a factory-to-pad basis. The spacecraft arrives at the Payload Preparation Room where it is integrated with other components for installation into the Orbiter, serviced and checked out. When ready, the payload is hoisted into the mobile Payload Changeout Room, which transports and installs the payload into the Orbiter for launch.

A Shuttle Carrier Aircraft, a modified Boeing 747-100 aircraft, will be used to transfer the Orbiters between the two launch and landing sites or to retrieve an Orbiter which has aborted to Edwards AFB or another auxiliary field. A Mate-Demate Facility at KSC and VAFB will be used to place the Orbiter onto, or remove it from, the Shuttle Carrier Aircraft.

KSC and VAFB will also have the necessary off-line maintenance, supply, support and management systems and facilities, including a sophisticated computer Launch Processing System used for automatic checkout, control and monitoring of the SSV and its components and information management, scheduling and work control.

## D. MISSION CONTROL SYSTEMS [redacted]

[redacted] The NASA Mission Control Center (MCC/JSC) is located at Johnson Space Center (JSC), Houston, Texas. The MCC will provide centralized control of the Space Shuttle for launch (at tower clear), orbital flight, entry, and landing until the Orbiter comes to a stop on the runway. Control includes the functions of vehicle management in the area of hardware configuration (verification), flight planning, communication and instrumentation configuration management, trajectory, software and consumables, payload management, flight safety, and verification of test conditions/environments. The MCC system will satisfy the following general support requirements:

a. Orbiter guidance and targeting

b. Trajectory determination and navigation

c. Orbirer systems monitoring and commanding

d. Trajectory monitoring and control

e. Inflight data acquisition and data information extraction necessary for execution of above functions.

f. Communication

g. MCC system development tools

h. Simulation and training

The MCC functional capabilities are allocated to three MCC systems:

1. Communication Interface System (CIS): Provides voice and data communications within the MCC and between the MCC and external circuits. Specifically, the CIS provides:

a. Preprocessing of Orbiter downlink data

b. Decommutation and transfer of downlink data to MCC data computation complex and display control system.

c. Transfer and formatting of data from MCC data computation complex to Ground Spacecraft Tracking and Data Network (GSTDN).

d. Interleaving of Shuttle Data Processing Complex (SDPC) commands with digital voice data and digital text and graphics data for Tracking and Data Relay Satellite System (TDRSS) uplink.

e. Recording and playback of telemetry dump data.

f. Voice communications between MCC and external locations.

g. Voice Analog-to-Digital (A/D) and Digital-to-Analog (D/A) conversion for A/G communications via TDRSS.

h. Voice communications and public address coverage within the MCC.

2. Display and Control System (DCS): The DCS provides the following functions and services within the MCC:

a. Conversion of computer generated data to video format.

b. Conversion of computer generated data to X-Y plotborad format.

c. Conversion of computer generated data to analog and bilevel Stripchart Recorder format.

d. Routing, switching and monitoring of video signals.

e. Routing and control of event data from Data Computation Complex (DCC) processors to console modules.

f. Conversion of command module switch inputs to DCC data format and route to DCC.

g. Conversion of display request switch inputs to DCC data format and route to DCC.

h. Hardcopy of TV displays.

i. Distribution of hardcopies within the MCC.

j. Consoles and console modules for controlling and monitoring spacecraft and MCC systems.

k. Centralized source for all timing signals.

3. Data Computation Complex (DCC): Provides computational, peripheral and switching capability within the MCC.

a. A multibus interface provides for dynamic switching among the various computational facilities.

b. The 360/75 computer complex provides primary non-realtime mission data processing support.

c. The Shuttle Data Processing Complex provides the capability for processing trajectory, command and telemetry function.

d. A Terminal Applications Support System consists of terminals both within and external to the MCC and the software to display program and mission data upon request.

A DOD Mission Control Center is required when and if DOD assumes flight readiness and flight control responsibilities for an Orbiter on a DOD mission. Upon assumption of such responsibilities a separate DOD Shuttle Operations and Planning Center (SOPC) will perform for DOD missions those functions described for MCC/JCS.

The Payload Operation Control Center: (POCC) is, within the context of the DOD STS, a geographically non-contiguous entity consisting of four major parts:

a. STC Mission Control Complex (MCC)

b. JSC/MCC DOD Payload Facility

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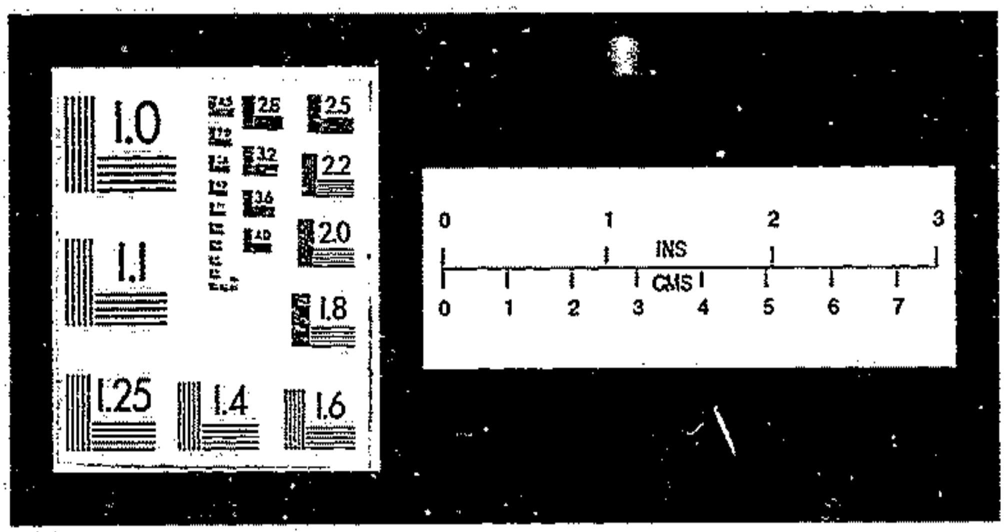

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c. KSC Payload Processing Facility

d. VAFB Payload Processing Facility

These components of the MCC are described in the paragraphs below.

STC MCC. The STC MCC, located at the Satellite Test Center, Sunnyvale, California, is a secure facility. The STC is a group of control complexes with the capability of providing the overall control and coordination of satellite missions. The STC Mission Control Complexes depend upon the SCF network for support of specific program requirements.

JSC/MCC DOD Payload Facility. The DOD Payload Facility at the JSC/MCC provides the secure interface point between the STC/MCC and the JSC/MCC. This facility consists of a secure room or rooms treated as a controlled access area. This area contains the communications security (COMSEC) equipment necessary to establish and maintain voice, teletype and data communication with the STC MCC. All equipment installations and signal lines passing into and out of this area shall meet TEMPEST (control of compromising electronic emanations) requirements. The JSC/MCC DOD Payload Facility provides the capability of maintaining secure communications with the STC MCC and unclassified or "sanitized" communications with the JSC/MCC. It also is used for materia's and documents.

KSC Payload Processing Facility. The KSC Payload Processing Facility (PPF) provides the equipment capabilities necessary to (1) receive, checkout and test the satellite(s) and the IUS, both separately and in their mated flight configuration and (2) establish an AFSCF interface for IUS/satellite tests conducted from the launch pad during preflight activities. The PPF accesses the AFSCF equipment in the Remote Vehicle Checkout Facility required to interface with the IUS/payload Space-Ground Link Subsystem (SGLS) and non-SGLS uplink(s) and downlinks. Contact is by hardware or data links to the IUS/satellite within the PPF or installed in the Orbiter on the launch pad.

The PPF also incorporates equipment and fixtures which can be used for receipt and storage of the payload(s) and for their individual checkout, mating, and acceptance testing prior to the delivery of the IUS/satellite combination to the Payload Changeout Room at the launch complex.

VAFB Payload Test Facility (PTF). The VAFB PTF interface with the PPR/PCR and with the Vandenberg Tracking Station (VTS) which, in turn, provides the Communications & Tracking (C&T) interface with the AFSCF.

These interfaces may consist of S-band, X-band, L-band or UHF carriers. The payload communication links may be relayed via VTS for processing or may be processed at the PTF itself.

A VAFB PTF is capable of processing and displaying the portions of the dedicated DOD payload downlink necessary for prelaunch checkout and validation. This processing and display capability includes decryption of the downlink if required. The VAFB payload specific PTF is also equipped to provide command capability to the satellite, either via hardline through the LCC or RF link via the PPR/PCR. These commands may be encrypted if required for compatibility with the particular satellite under checkout.

These processing and command activities are coordinated with the STC and the JSC/MCC by means of a secure voice conference circuit. The VAFB PTF also communicates with the orbiter crew via the LCC voice circuit during prelaunch checkout.

E. DoD Operations Concept [redacted]

[redacted] Command and Control of an Orbiter flying a DoD mission prior to 1982 will be via MCC/JSC using the NASA communications network. The IUS communications and tracking functions will be supported by the SCF. Control of the DoD satellite becomes the responsibility of the SCF upon deployment from the Orbiter. SSV flight planning, training and data load preparation will by performed in an unclassified manner by NASA. IUS flight planning, training and data loads will be prepared by DoD.

The first classified DoD STS mission is currently scheduled for 1982. Command and control during the era from 1982 until operational capability exists at a dedicated DOD facility will remain essentially the same as during the near term. There are several concepts concerning flight planning and flight readiness during that era.

Exception Mode - For not more than four classified flights per year, JSC dedicates its facilities to the classified DoD operations. SSV flight design is performed by DoD in a classified DoD or DoD Contractor facility. NASA would continue to perform data loads, and training for the SSV. IUS, flight planning and flight readiness would be the responsibility of DoD.

Controlled Mode - One flight control room at JSC would become dedicated to DoD flight operations while the other flight control rooms

continue NASA operations. The DoD data stream and display access would be isolated and one flight control computer facility would be manned by cleared personnel. Flight design, and data load responsibilities for the SSV and the IUS would be the same as for the Exception Mode.

Dedicated Facility - If this option is exercised, DoD would acquire a Shuttle Operations and Planning Center (SOPC) to be located at a to-be-determined (TBD) mid-CONUS location. SSV and IUS flight design, data loads, training and flight control would be conducted by DoD at this dedicated facility.

Current projected STS missions can be grouped into six basic categories:

- Delivery of satellites to orbit.

- The placement and recovery of satellites in low earth orbit.

- The deliverance and contingency retrieval of a propulsive stage and a satellite into earth orbit.

- The Orbiter functioning as a low earth orbiting manned observation platform.

- The Orbiter performing as an orbiting laboratory and test bed.

- The inspection, servicing and repairing of satellites in low earth orbits.

## F. NASA Reference Missions Performance Requirements [redacted]

[redacted] The spectrum of payloads for projected missions includes satellites, expendable upper stages, and sortie modules for a variety of scientific, technical, and logistic activities. Some of the satellites and all of the sortie modules are scheduled to be recovered and returned to earth.

## G. Communications and Tracking Overview [redacted]

[redacted] The communications and tracking subsystem is a mixture of DoD and NASA facilities which include the TDRSS, GSTDN, NASCOM (NASA Communications Network) and AFSCF. These basic systems will be supplemented, as required, by special leased facilities or dial-up terrestrial communication services. NASA's NASCOM, TDRSS, and GSTDN communication facilities support the Orbiter through prelaunch,

ascent, on-orbit, and landing phases. DoD C&T facilities will support the checkout and monitoring of the DoD payloads during prelaunch, ascent, and on-orbit operations. All communications links supporting the STS and payloads will be encrypted during DoD missions. Probably none of these will be encrypted during NASA missions.

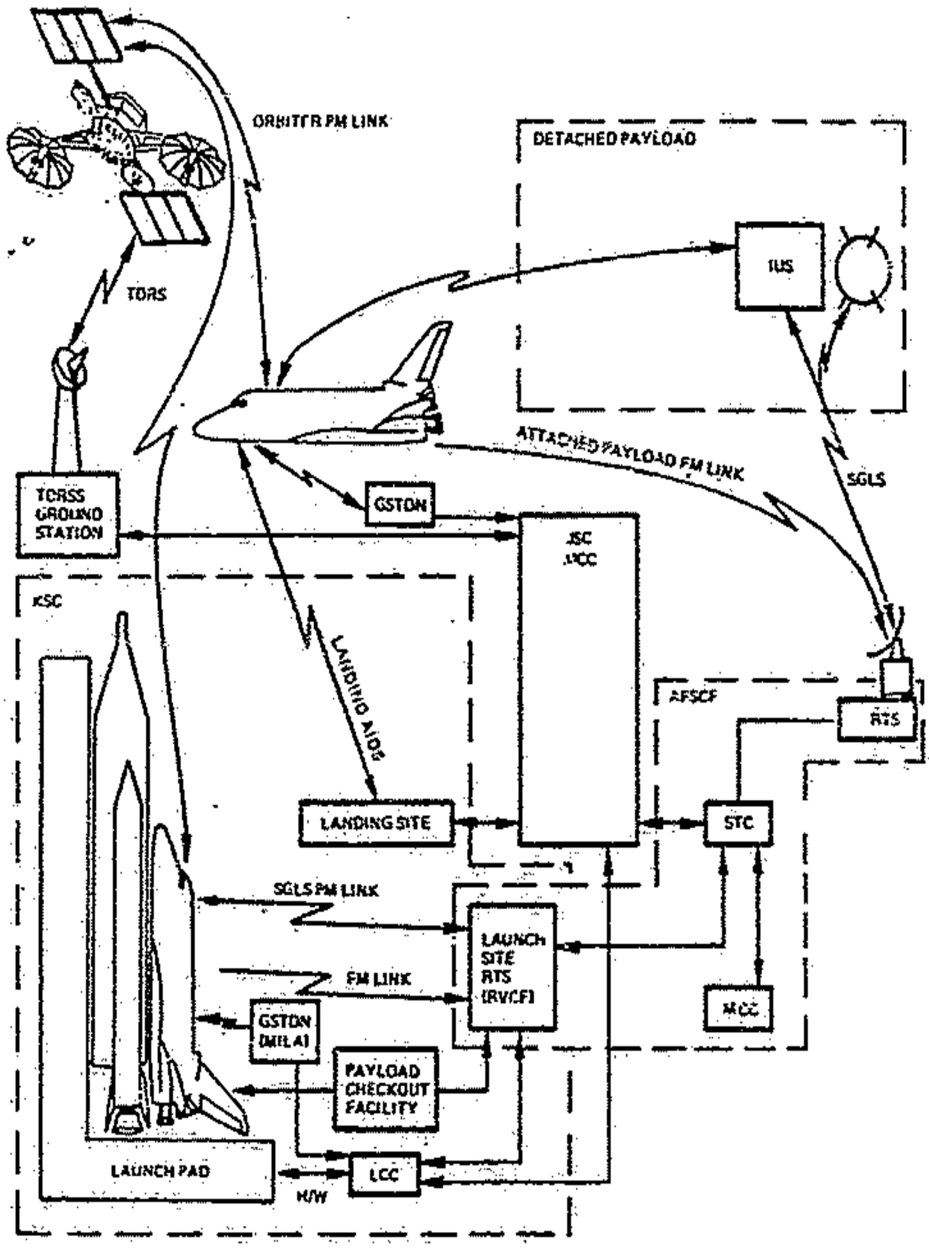


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Figure 6. Early Mission Operations C&T System Overview



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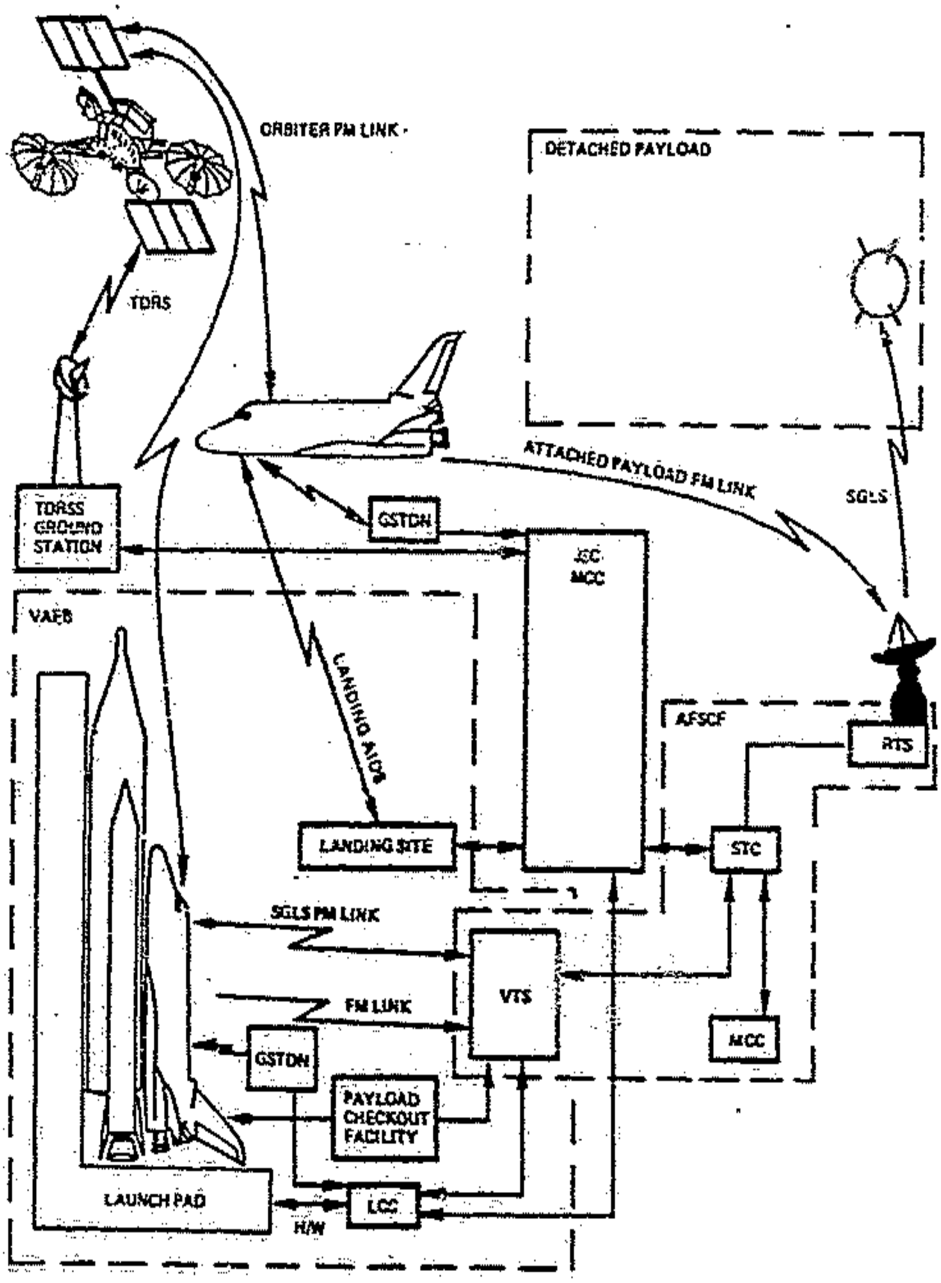


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Figure 7. VAFB C&T System Overview [redacted]

KSC Only Mission Operations System (MOS) C&T Functional Requirements.

Prelaunch:

a. IUS/Satellite-to-AFSCF secure/nonsecure telemetry and command verification.

b. Orbiter-to-AFSCF secured FM telemetry verification.

c. IUS/Satellite readiness monitoring and control.

d. POCC-to-MCC coordination.

e. Tracking support verification.

Ascent:

a. IUS/Satellite status monitoring.

b. Ascent tracking.

c. Range safety.

d. MCC/STC-to-MCC/JSC coordination.

On-Orbit:

a. IUS/Satellite status monitoring and control.

b. On-orbit tracking.

c. IUS/Satellite checkout and handover.

d. MCC/JSC-to-MCC/STC coordination.

Landing:

a. Contingency tracking support.

b. Post-landing support.

Besides those requirements listed previously, VAFB C&T has additional requirements:

Full (KSC & VAFB) MOS C&T Functional Requirements:

Prelaunch:

a. LCC (VAFB)-to-MCC/JSC mission coordination.

b. VAFB ascent tracking verification.

c. VAFB landing operations verification.

d. Orbiter-to-MCC/JSC communication verification.

e. LCC (VAFB)-to-MCC/JSC launch coordination.

Ascent:

a. VAFB ascent tracking.

b. VAFB range safety.

c. MCC/JSC-to-VAFB ascent coordination.

On-Orbit:

Same as KSC-Only Early Mission Operations.

Landing:

a. Landing operation support.

## H. Tracking and Data Relay Satellite System (TDRSS) [redacted]

[redacted] The TDRSS is a system of two satellites in geosynchronous orbit at 319°E and 189°E longitude stations, plus one on-orbit spare and a second spare on the ground. The on-orbit spare is located near the center of the TDRS pair where the time to reach either the TDRS East or West station is minimized.

The two active TDRS are normally positioned so that they will have line-of-sight transmission to the TDRS ground station at White Sands and therefore provide low earth-orbiting satellites with coverage approximately 85% of the time. Figure 9 shows the TDRSS configuration.

TDRSS Coverage. The two TDRS spacecraft will provide the potential for near-global, real-time coverage (approximately 85 percent of each orbit). The zone of exclusion (i.e., area in which coverage cannot be provided) is shown in Figure 10 for vehicles at a 200 km altitude and a 1000 km altitude. Full coverage can be provided for orbital altitudes greater than 1200 km. The zone of exclusion represents the lower altitude coverage limits for the TDRSS users. The upper altitude coverage limit is at 12,000 km for the Single Access system, when viewed at the limb from the TDRSS (worst case). Coverage as a function of altitude is shown graphically in Figure 11.

Orbiter and TDRSS Usage and Frequency Assignments. The Orbiter and TDRSS will use S-band and Ku-band, as appropriate to the constraints which may be present, such as the inability to deploy the Ku-band antenna during ascent, Orbiter attitude, and time-sharing the Ku-band antenna with the rendezvous radar. Frequencies and required bandwidths for all space-to-space communications links are summarized in Figure 12.

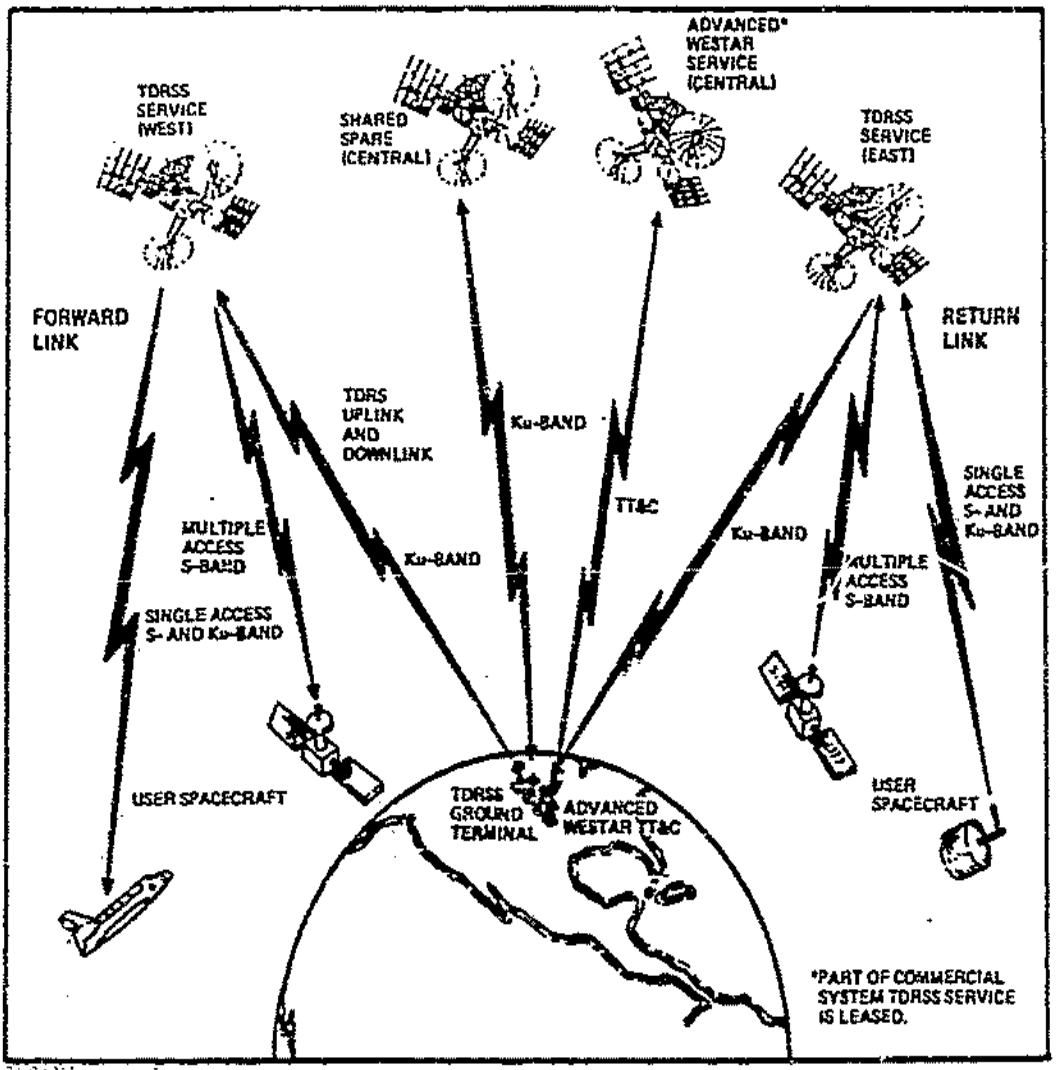


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Figure 9. TDRSS Space Segment Configuration [redacted]

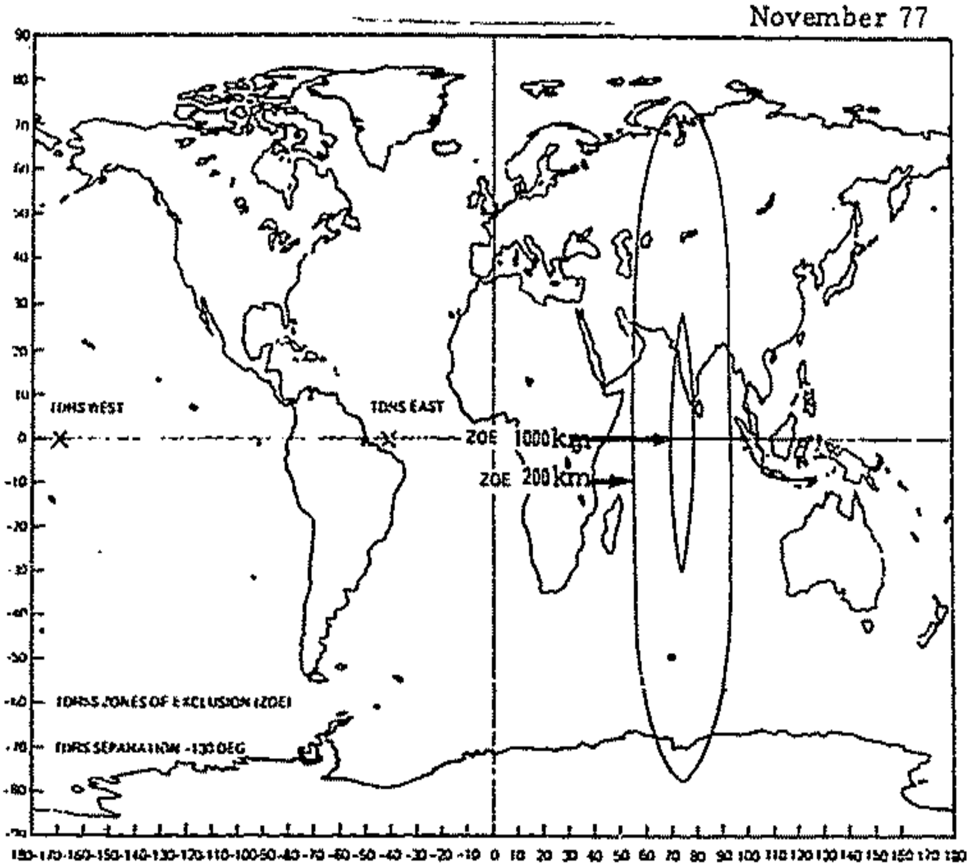


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Figure 10. TDRSS Coverage (U)

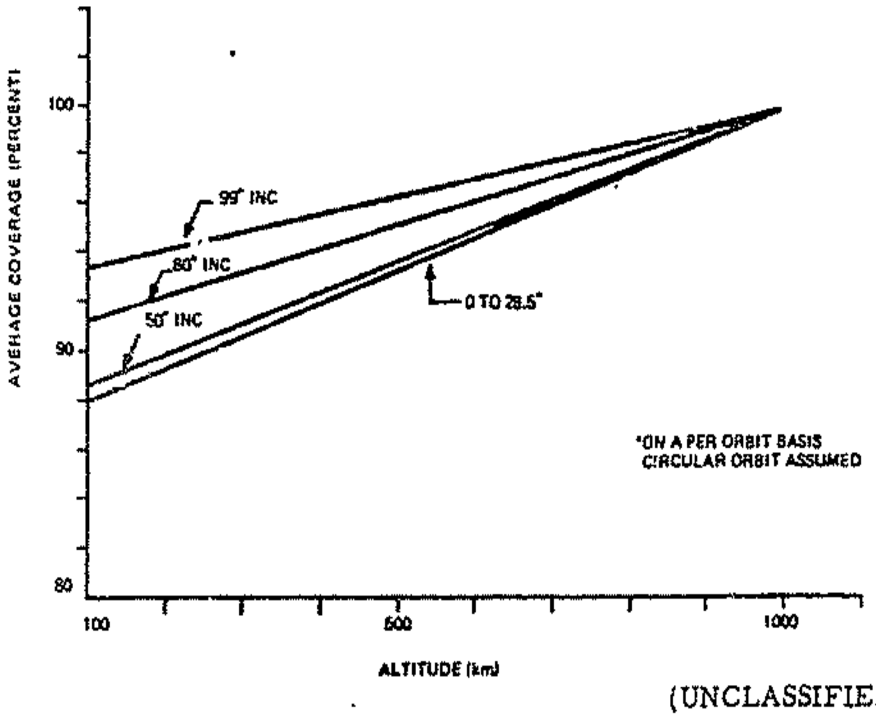


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Figure 11. TDRSS Coverage versus Altitude and Orbital Inclination [redacted]

| Service Link and Function | Communications Sublink | Frequency | Comments |
|---|---|---|---|
| Forward Link (User Command Data, Tracking Signals and Voice Transmission) | Ground to TDRS* | 14.6 to 15.25 GHz | |
| | TDRS to User | 2106.4 MHz (MA)<br>2025.8 to 2117.9 MHz (KSA)<br>13.4 to 14.05 GHz (KSA) | NASA Required Bands |
| Return Link (User Telemetry Data, Return Tracking Signals and Voice Transmission) | TDRS to Ground** | 13.4 to 14.05 GHz | |
| | User to TDRS | 2287.5 MHz (MA)<br>2200 to 2300 MHz (SSA)<br>14.6 to 15.25 GHz (KSA) | NASA Required Bands |

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* Includes TDRS Command and Pilot Tone
** Includes TDRS Telemetry

Figure 12. Frequency Bands for TDRSS Telecommunication Service

<u>TDRSS-to-Orbiter Link.</u> The following is a summary of the TDRSS to Orbiter (forward) link characteristics:

a. S-band and Ku-band links to the Orbiter are spread spectrum.

b. S-band and Ku-band links are PSK modulated.

c. S-band data format at multiplexer interface is NRZ-L.

d. Data rates are 72 kbps and 32 kbps on S-band links and 216 kbps for Ku-band.

e. Convolutional encoding (R=1/3, K=7) is used on S-band.

f. S-band transmitted data format is BI-Ø-L.

<u>Orbiter-to-TDRSS Link.</u> The following is a summary of Orbiter to TDRSS (return) link characteristics:

a. S-band link is phase shift keyed (PSK) modulated.

b. Ku-band is quadriphased shift keyed (QDSB/QPSK) modulated in two modes, each consisting of three channels.

c. Convolutional encoding (R=1/3 K=7) is used on the S-band link.

d. Convolutional encoding (R=1/2, K=7) is used on the Ku-band link, Mode 1, channel 3.

e. S-band data format at multiplexer interface is NRZ-1; transmitted format is BI-Ø-L.

f. Use of spread spectrum is optional for TDRSS, but present plans do not require it on the links which do not impinge on the earth.

## III. Scenarios (U)

(U) The exact nature of the environment in which the STS will be called upon to operate is undetermined. The purpose of this section is to characterize five military/political situations the U. S. could conceivably face and in which the STS might be employed.

### A. Case 1 (U)



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(U) For a classic example of what the Soviets are able to learn about U.S. space systems from presumed open source information, see the article reproduced in Appendix I, "The Pentagon's Global Espionage Network" which was published in the Soviet periodical, Aviation and Cosmonautics, May, 1972.

c. Laser Tracking (U)

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(U) Lasers, as trackers, have the advantage of being usable in cases when the reflected sunlight may not give good visual detection; and the signal to be detected is at a known wavelength. On the other hand, the use of lasers is impaired by cloud cover.

6. Detection of Orbiter in Low Parking Orbits (U)



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c. GPS-Type Orbits (U)

d. SDS-Type Orbits (U)

(U) The SDS has an elliptical orbit with a 12-hour period, an apogee of about 38 600 km and a perigee of about 1 580 km. The inclination is 63 degrees (Figure 29).



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(2) Booster Guidance Accuracy (U)

(U) Direct ascent trajectories can be flown with relatively low inertial guidance error because the flight time is short. Very few analyses have been conducted to the present time; however, estimates for a few cases are shown in Figure 38. The radius of the sphere including 95 percent of the cases may be obtained by multiplying SEP values by 1.8.

6. Nuclear ASAT (Far Term) (U)

8. Nuclear ASAT Summary (U)

(U) Nuclear effects are briefly reviewed in Appendix III. Figure 38 summarizes the nuclear attack possibilities.

9. Laser Threat

Introduction: We have limited information on the detailed characteristics of Soviet laser systems. Fluence levels and intensities of the Soviet laser threats described in this section are based on U.S. laser technology.

a. Laser Threat (Surface Site) (U)



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(2) Jamming (U)

c. Estimates of Jamming ERP (U)

(U) The basis for the tables giving ERP values is discussed below.

d. Jammer Type (U)

Jamming is logically divided into two types: continuous jammers and pulse jammers.

(U) Continuous jamming may involve either noise or tones (broad band or narrow band). No significant distinction will be made here since the choice does not dramatically affect the power levels which can be generated. The designer should keep in mind that either possibility exists, however. Continuous jamming is used here to mean that the jamming signal is transmitted continuously, not in bursts, as in pulse jamming.

(U) Pulse jamming has the principal advantage in higher power generation which is made possible by using pulses of radio frequency energy instead of continuous waves. In addition, some radar hardware may be directly convertible to pulse jamming. In general, the shorter the duty cycle (the smaller percentage of time the transmitter is operating) the higher the peak power that can be generated. Therefore, the threat can contain short intense bursts of RF energy.

e. Jamming Platform (U)



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(U) Current state of the art for commercially available klyst. ns at 15 GHz is 1 to 2 kW. A 20-kW to 30-kW tube has been experimentally demonstrated, but there are some problems in obtaining a reliable tube.

g. Candidate Soviet Antennas for Jamming (U)

(U) The size of the jamming antenna is limited by the pointing accuracy requirements for narrow beams of large antennas.

2. Passive Electronic Warfare (U)

a. Discussion (U)



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## D. Physical and Intelligence Threats to the STS (U)

### 1. Physical Threat to Facilities/Elements (U)

### 2. Intelligence Threat to STS Facilities and Operations (U)

(U) This section is based on information provided by USAF Office of Special Investigation. (Reference 14) In order to effectively attack STS ground facilities and operations, detailed knowledge of physical layout, security procedures, operating procedures, etc., is desirable. Given the large amount of information concerning the STS which is available from unclassified or public sources, knowledge of system vulnerabilities must be presumed.

(U) Some areas within the U.S. are closed to certain official representatives of hostile nations. Most of these restrictions apply to Soviets. The limitations do not apply to some United Nations employees, tourists, or citizens visiting the U.S. under various exchange agreements. Since no federal agency either polices these travel restrictions or investigates violations thereof, the extent of adherence to these limitations is unknown. Violations are known to have occurred.

3. Threat to Physical Security (U)

a. (U) Activities by vandals and pranksters is highly probable. Since they usually act on the "spur-of-the-moment", there is little opportunity for forewarning. On the other hand, their activities do not usually directly or significantly impair operations capabilities. Also, reasonable physical security precautions usually deter potential perpetrators or minimize the effects of their acts.

b. (U) The threat posed by dissidents, radicals, anarchists, or terrorists is somewhat more serious but low probability. Domestically, there are several groups which have demonstrated the capability to conduct activities, primarily bombings, which could seriously impair the STS efforts. Among the most significant are Puerto Rican Nationalist Groups, Cuban exiles, and Croation Nationalists. Although there is no information that any of these groups has targeted the STS, the threat that they pose would be significant should any one of them so target the STS. Similarly, on the international scene, West German, Japanese, and Palestinian Groups, among others, have all demonstrated the capability to carry our sophisticated transnational operations which, if directed against the STS, could have very serious adverse consequences. None is known to be targeting the STS. The dissident threat emanates from environmental and other groups which may espouse legitimate concerns but which could conceivably resort to spontaneous or planned violent activity against STS facilities should they perceive an exploitable "issue".

## 4. Factors Bearing on the Threat at Various STS Locations (U)

a. (U) KSC - The areas adjacent to KSC are designated as restricted to some official Soviet and other communist nation personnel. There are no official or commercial establishments of hostile nations near KSC. The port of Tampa, Florida, is open to Soviet ships. Cuban exile groups have operated in Florida.

b. (U) VAFB - The areas immediately adjacent to VAFB are designated as restricted to officials of hostile nations. There is a Romanian establishment in Los Angeles, California, about 90 miles from VAFB. The Ports of Long Beach and Los Angeles, California, are open to Soviet vessels.

c. (U) JSC - None of the areas surrounding JSC is restricted. There are no establishments of hostile nations in the vicinity. The ports of Brownsville and Beaumont, Texas, are open to Soviet ships.

e. (U) Owens Matheson - This chemical plant is the sole producer of monoethylhydrazine shuttle rocket fuel. None of the adjacent areas are designated restricted. There are no hostile establishments in the vicinity. The ports of Burnside and Baton Rouge, Louisiana are open to Soviet Ships.

f. (U) White Sands - The adjacent areas are restricted to certain officials of hostile nations. There are no official or commercial establishments of hostile nations in the vicinity of White Sands, New Mexico.

E. Nuclear Collateral Damage Threat (U)

1. Collateral Threat Environments (U)

(U) High altitude nuclear detonations above about 30 km can produce a number of environments which can be detrimental to the operation of the STS. The Orbiter, IUS and TDRSS within line-of-sight of such bursts would be exposed to prompt neutrons, gamma, and X-ray radiation. The magnitude of this radiation even at geosynchronous altitude is sufficient to "upset" unhardened electronics. At low altitudes (100-500 km), the radiation may be severe enough to cause permanent damage in unhardened electronics and tissue damage in humans. The probability of being within line-of-sight of a given burst is small because of the "shadowing" effect of the earth and the percentage of the flight so exposed is dependent upon both the burst parameters and the spacecraft orbit parameters. Decaying fission debris from high altitude bursts emits betas, alpha particles and gamma radiation and neutrons. If the relative geometry of the burst and STS spacecraft is such that the expanding debris intercepts the STS orbital path, some debris can plate out on the spacecraft and result in local sources of radiation. Another debris produced environment

is the formation of artificial radiation belts due to the trapping of the emitted electrons in the geomagnetic field. Spacecraft operating in these trapped electron belts, traversing the belts, or being traversed by the initial beta tubes will experience effects which can temporarily or permanently upset their operation. Because the trapped electrons become distributed along magnetic fields around the earth in a relatively short period, the probability of exposure is effectively unity. Most of the effects of this environment are due to the total dose accumulated while on orbit. Even for short missions, trapped electron environments from high altitude nuclear tests or wartime ABM activity can result in damage to electronics as well as exposing human operators to debilitating or lethal doses. The enhanced trapped electron belts can persist for long periods, some as long as a year. Repeated Orbiter missions in these belts can result in the accumulation of large doses in the electronics.

## 2. Blackout/Electromagnetic Pulse (EMP) (U)

(U) Both blackout and EMP result from high altitude nuclear explosions. Both phenomena have the potential for disrupting Orbiter-IUS-TDRSS communication links or damaging communication receivers. The output of a nuclear detonation consists of neutrons, X and gamma radiation, and debris. This environment in turn creates the blackout and EMP effects. Nuclear effects are discussed in detail in Appendix III.

APPENDIX I

# THE PENTAGON's GLOBAL ESPIONAGE NETWORK

[redacted] This article was written by Colonel-Engineer Yu. [illegible] and Major-Engineer L. Shevchuk, and appeared in the Soviet Periodical "Aviation and Cosmonautics" (Aviatsiya I Kosmonavtika) 5 May, 7[illegible].

American imperialism continually confirms its aspirations to play its characteristic role of guarantor and defender of an international system of exploitation and oppression. Everywhere the imperialists strive to predominate; interfering in the affairs of other nations, unceremoniously violating their lawful rights and sovereignty. Employing force, bribery and economic intervention they attempt to impose their will upon governments and even whole regions of the world. Convincing evidence of the militaristic goals of the USA's ruling circles is its active intelligence system, their special efforts toward perfecting its forms and methods and the appropriation of huge sums of money for these purposes. The goals of this global espionage network became clear in the Korean and Indo China wars as well as in U.S. support of the aggressive policies of the Israeli militarists.

The Recon Satellite Program long ago took a firm place in the Pentagon's global espionage system. It now plays a major role in the American Military Command's strategic intelligence. Work concerned with the establishment of a space reconnaissance system was begun in the U.S. long before the first artificial earth satellite was put into orbit and continues on an ever-increasing scale.

The USA's reconnaissance satellites are employed in the collection of photo, radio, electronic, television and radar intelligence, as well as the detection of nuclear detonations and ballistic missile launches, both from ground-based launch sites and submarines. These satellites are controlled by a Command Center in Sunnyvale, California which guides the work of the entire complex, including the ground stations in the U.S. and overseas.

In order to obtain high-interest information the Pentagon employs both broad-scale and pinpointed photographic satellites launched into near-polar orbits with perigees from 120 to 200 kilometers. With these photo satellites the Pentagon is able to maintain regular surveillance of missile launch sites, airfields and troop distribution, particularly tank units.

Satellites which conduct broad-scale photo reconnaissance are equipped with wide-angles lens cameras, intended for photography of large areas with a relatively low resolution capability. This method allows photography of entire territories which are of interest. Using these broad-scale photos, mission planners are able to determine the more important objectives for coverage by photo satellites with a pin-point capability.

At the present time the U.S. is conducting broad-scale photo reconnaissance utilizing satellites launched under the "Discoverer" and the "770" Programs. A typical orbit for these vehicles is elliptical, with a perigee of 160-200 kilometers, an apogee of up to 450 kilometers and an inclination of 75 to 90 degrees. Useful life of these satellites, as a rule, does not exceed 3-4 weeks. The photographic film expended during orbit is ejected from the spacecraft in containers which are retrieved in the air by specially configured aircraft. Moreover, the film drop is calculated so that the containers will land in the sea in the event of an unsuccessful airborne retrieval attempt. To make the containers easier to recover they are equipped with homing beacons and sea marker dye devices.

According to public reports the later models of the spacecraft in the "770" Program are equipped for communications and radar intelligence collection, in addition to photo reconnaissance. The communications intelligence information in the form of tape recordings of radio and radar emissions are ejected from the spacecraft along with the expended photographic film. The radar equipment permits all-weather reconnaissance and facilitates the detection of objectives hidden under foliage or even several centimeters of earth.

The pin-point photo satellites are employed for photographing specific areas, which are revealed in analysis of the broad scale photography. Low perigees are characteristic for these vehicles -- from 130 to 145 kilometers. This low perigee, in combination with telescopic lenses make it possible to obtain photographs with a resolution of 1.8 to 5.5 meters (according to some sources even down to 0.3 meters).

From 1962 thru 1964 there were 12 to 14 broad-scale photo satellites launched each year. Beginning in 1966 the number of launches of this type satellite was reduced to 8 or 9. In addition, the photography was already being accomplished without overlap, since the maps apparently were already complete and required only refinement.

The total orbit time of photo reconnaissance satellites is approximately 180 days a year. There are 8-9 pin-point photo reconnaissance vehicles launched each year. An exception to this average was in 1966, when 15 of this type were launched.

The next step in the development of a satellite reconnaissance system was Program "647". The spacecraft developed under this program have a multifaceted mission. They are intended to simultaneously accomplish such tasks as detection of ICBM launches, conduct of photo and communication reconnaissance, recording of troop movements, surveillance of military objectives, pin-pointing locations of nuclear detonations, guidance of nuclear strikes and conduct of strategic weather reconnaissance. Such a spacecraft weighs approximately 800 kilograms, is 7 meters long and 3 meters in diameter. These launches were begun in 1970.

The "647" series satellites in synchronous orbits not only have the capability for surveillance of the equatorial and temperate latitudes but also the areas of the North and South Poles. Information is transmitted from orbit to ground station by radio. In addition expended photo film and magnetic tape can be returned to earth in containers.

While recognizing the merits of satellites as a means of conducting strategic reconnaissance, American specialists also point to their disadvantages. One of the basic shortcomings of the photo reconnaissance satellites, in their opinion, is that they do not have the capability to provide information on a real-time basis. From the time the pictures are taken until they are processed and analyzed, even in an ideal situation, several dozen hours may have passed. During this time the situation may change drastically. In addition, broad-scope photography yields a multitude of pictures which are of no intelligence value.

Several years ago attempts to establish a television capability on the reconnaissance satellites ended in failure. This was due primarily to the low resolution capability of television equipment (as compared to still camera equipment) and the difficulties encountered in the transmission of the television pictures back to earth. However, since the time the first experiments were conducted the television systems have been greatly refined. Transmitting tubes have been developed which provide a resolution capability approaching that of conventional photography. They are already being utilized on the broad-scale photo satellites.

The Pentagon attaches no small importance to the role of satellite systems in electronic reconnaissance. Special satellites are utilized to determine the characteristics and deployment of ground-based radar and communication stations and to intercept radio signals which can be detected by ground-based intercept stations only within line-of-sight limitations. One of the space systems most widely used by the Americans for electronic intelligence collection is the "ferret" satellite. These satellites, weighing more than one ton, are 6.7 meters in length and 1.5 meters in diameter. They are designed for electronic and communication intelligence collection, especially intercept of communications with ships and submarines at sea and between various military organizations and their respective headquarters. According to some reports, the satellites are capable of intercepting traffic from low-powered transmitters, for example the type of transmitters used by intelligence agents. The intercepted information is recorded on-board the spacecraft and then down-linked when the spacecraft passes over its tracking stations. Typical for the "ferret" satellites is a near-earth circular orbit at an altitude of approximately 500 kilometers with an inclination of 75 to 82 degrees.

A similar mission is assigned to the P-11 electronic surveillance satellites. These vehicles weigh 60 to 160 kilograms with a maximum length of 0.9 meters. They are launched into orbit along with the photo reconnaissance satellites as a supplementary payload.

In order to upgrade the operational effectiveness of the electronic intelligence-gathering systems the Lockheed firm, on contract to the U.S. Air Force, is developing a new photo and electronic intelligence satellite called "Sigint". These satellites are to replace not only the "Ferret" and "P-11" programs but also the reconnaissance aircraft and ships which constantly patrol the periphery of the Soviet Union. The Sigint satellites are equipped with a control system capable of orientation on three axes, a precision stabilization system and a power plant which uses both Solar elements and chemical batteries. They are also equipped to generate electronic interference. The Sigint satellites, weighing over ten tons, are launched into a circular Polar orbit with a perigee of 185 kilometers for conduct of reconnaissance over foreign territories. The Sigint satellite is to pass twice in each 24-hour period over Buckley Air Base in Colorado, where special equipment is installed to receive information transmitted from on-board the spacecraft.

In 1963 the USA started launching satellites for the detection of nuclear detonations on the earth's surface, in the atmosphere and in deep space.

Equipment on board such satellites includes detectors for Roentgen rays, Gamma rays and Neutron flux, as well as devices for the measurement of background radiation and an electron-protron spectrometer. This equipment registers radiation and particle flux from both man-made nuclear explosions and increased solar activity. For this reason, data received from these satellites was used in the pre-launch preparations for the manned Apollo missions to ensure the safety of the Astronauts.

A feature of the method now in use for the detection of nuclear explosions and Solar flares is that the satellites are launched into orbits with perigees of 90-110,000 kilometers. According to published reports twelve such satellites are included in the present program, which allows around-the-clock surveillance of the entire surface of the earth and near-earth space.

Notwithstanding these various means of space reconnaissance, the USA's work in this area is not limited to special-purpose space systems for military purposes. For instance, methods of detecting ICBM launches were studied during the Gemini space-flight program. The Gemini crewmembers, using special equipment, made numerous fixes on missile launches from ground test ranges and registered infrared radiation from missile engines both in flight and on special ground-testing stands. When photographing the earth's surface from space the Apollo crews employed the same super-sensitive film being used on the reconnaissance satellites. It was not without reason that the Department of Defense and the Atomic Energy Commission refused to release most of these photographs to the public. It was released to the press that Defense Department specialists regularly examine photographs received from the NASA Tiros and Nimbus weather satellites.

Military circles in the USA are showing considerable interest in the experimental mapping satellites. These satellites are compiling maps for use in land-management programs, geological and agricultural-improvement studies, as well as maps of the continental shelf, bays, estuaries and other coastal areas which may be hazardous to navigation. These satellites are to be equipped with color television cameras with a resolution of 60 meters on photographs taken from a Polar orbit at an altitude of 900 kilometers. In the case of real-time transmission the resolution capability of this equipment will increase to approximately double. For these reasons the Pentagon is very interested in this type of satellite.

Another object of considerable interest within the U.S. military command is the Skylab orbital space station. Scheduled for launch in 1973, the Skylab will conduct scientific, technical and biomedical experiments as well as several experiments for Defense Department programs.

In order to support this type of station and also to accomplish some independent U.S. Air Force missions, study is under way for a re-usable transport vehicle to fly earth-to-space and space-to-earth shuttle missions. Such a vehicle would be capable of maneuvering in space to accomplish a wide range of military missions (reconnaissance, inspection of and, if needed, destruction of an enemy's satellite as well as repairs on its own vehicles either with or without return of the vehicles to earth).

According to U.S. Air Force plans this type of shuttle vehicle would be used to launch reconnaissance satellites and other systems of a military application, deliver expended film capsules to earth, inspect enemy satellites and carry out independent military missions of up to 48 hours duration.

The projects just outlined do not cover the full scope of the U.S. military-industrial interests in the development of space-satellite reconnaissance systems. The USA's reconnaissance program is developing steadily toward increased operational effectiveness with the goal of attaining military superiority over the countries of the socialist camp.

But the leaders of the Pentagon should not content themselves with such vain illusions. In the words of comrade L. I. Brezhnev, speaking at the twenty-fourth congress of the Communist party of the Soviet Union, "We have all the means required -- an honest policy of peace, the military might, and the unity of the Soviet people -- to protect the inviolability of our borders from any encroachment and to protect the achievements of Socialism". Still the troops of the Soviet armed forces must not forget the global espionage of the American imperialists, but must exhibit the utmost in organization and vigilance.

# APPENDIX III

## NUCLEAR EFFECTS [redacted]

### 1. Introduction to Nuclear Effects [redacted]

[redacted] Independent of where it occurs, the output of a nuclear detonation consists of neutrons, X- and gamma radiation and debris. These products are created when some of the mass of the weapon is transformed almost instantaneously by nuclear reactions into tremendous quantities of energy. Some of the resulting environments persist only a few shakes (1 shake = $10^{-8}$ seconds) after the detonation while others endure for days, months, or even years.

### 2. Endoatmospheric Bursts [redacted]

[redacted] First, we will address the prompt radiation emitted from a burst in the atmosphere. In this case the weapon X-rays are deposited in the surrounding air, heating the air to high temperature. The superheated region called the fireball expands and cools, radiating thermal energy in the optical infrared (IR) spectrum. The high temperature in the fireball creates tremendous pressures at the expanding edge of the fireball, thus forming a shock front. This spherical shock front expands creating high overpressures, high velocity transient winds, thermal effects, and powerful ground shocks. Gamma radiation and neutrons make up only about three percent of the total detonation energy. While only about one percent of these radiations escape the burst environment, they can produce significant casualties to personnel and damage to electrical and electronic equipment and exposed structural elements (transient radiations effects on electronics, TREE). The relative significance of the above environments for systems operating in the atmosphere depends primarily on two factors, the burst yield and the range to the receiver. For low yields the prompt radiation effects tend to dominate but as yield increases, overpressures of significance tend to extend beyond the range of prompt radiation effects. As yield continues to increase, the thermal effects begin to overtake the blast and finally become dominant. Figure III-1 illustrates this principal. Other environments which may be produced by atmospheric burst include blackout, redout, and electromagnetic pulse. Each of these environments will be treated individually later.

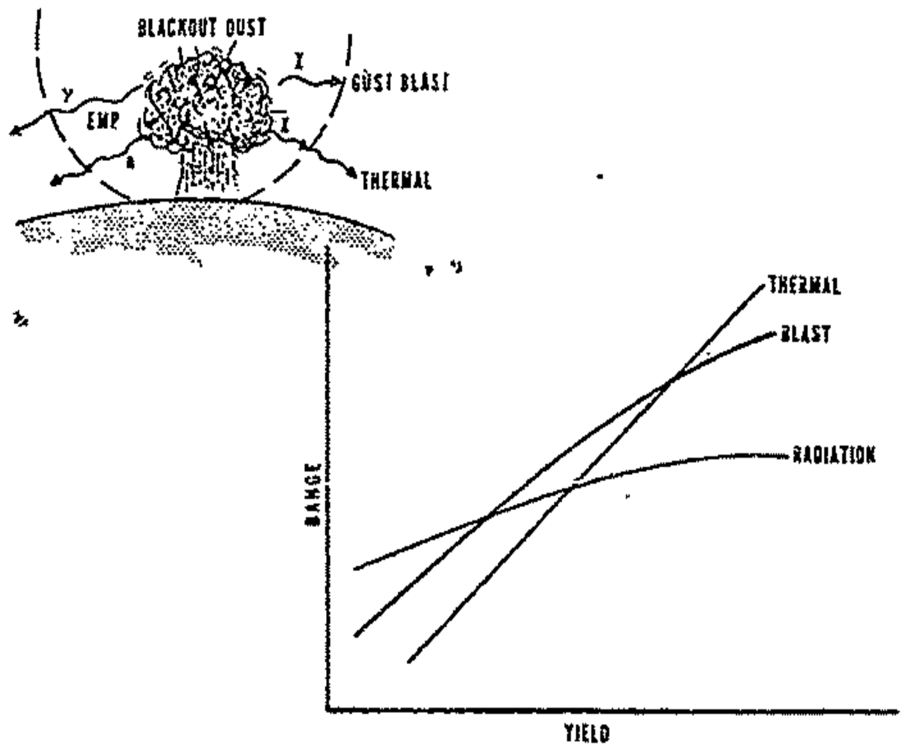


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Figure III-1. Endoatmospheric Burst Environment [redacted]

## 3. Exoatmospheric Bursts [redacted]

### a. Radiation [redacted]

(U) For exoatmospheric detonation (above 100 km altitude), while the radiation output is the same as for endoatmospheric detonations, the lack of an atmosphere results in qualitative differences in phenomenology. The prompt radiation (x-ray, gamma, neutrons) and weapons debris expand radially outward from the burst essentially unattenuated. (See Figure III-2). The X-rays, which at low altitudes are deposited in the air around the burst point thereby forming the shock wave, traverse great distances in a vacuum. The downward expanding X-rays are absorbed in the atmosphere between 40 and 80 km depending on their spectral energies and may cause local heating. Satellites whose line of sight to the burst does not traverse the sensible atmosphere will be exposed to the X-radiation attenuated only by spherical divergence. The exposure of a satellite to X-radiation is by convention stated as energy fluence in units of calories/sq cm. The absorbed dose is expressed in units of either Radiation Absorbed Dose (RAD) (specified material) or calories/gram of specific material. Since the absorption characteristics of materials are a strong function of X-ray energy, it is necessary to integrate the combined X-ray spectrum and mass absorption properties over the entire range of X-ray energy to calculate the dose.

(U) The primary damage mechanism of X-rays is ionization. Because of the wide range of X-ray energies and spectra, this damage is manifested in a variety of ways, depending on the composition of the absorbing material. The low energy, "cold" X-rays are easily absorbed by materials. The rate of energy deposition is high and the material is heated almost instantaneously. In extreme cases, surface vaporization, or "blowoff" may occur. Internal stresses due to rapid heating may cause a shock wave in the material resulting in spallation of either the front or rear surface, or delamination of dissimilar materials. The high energy, "hot" X-rays produce effects similar to the cold X-rays on the interior of the satellite as opposed to surface effects. In addition, X-rays that penetrate the electronic circuits produce photo currents that could lead to transient upsets, or device burnouts. The System Generated Electromagnetic Pulse (SGEMP) will be discussed separately.

(U) Gamma radiations differ from X-radiation because of higher energies and origin during a nuclear reaction. The high gamma-ray energies are very penetrating and, therefore, it is not practical to shield spacecraft components from them, whereas X-ray shield is often feasible. Gamma

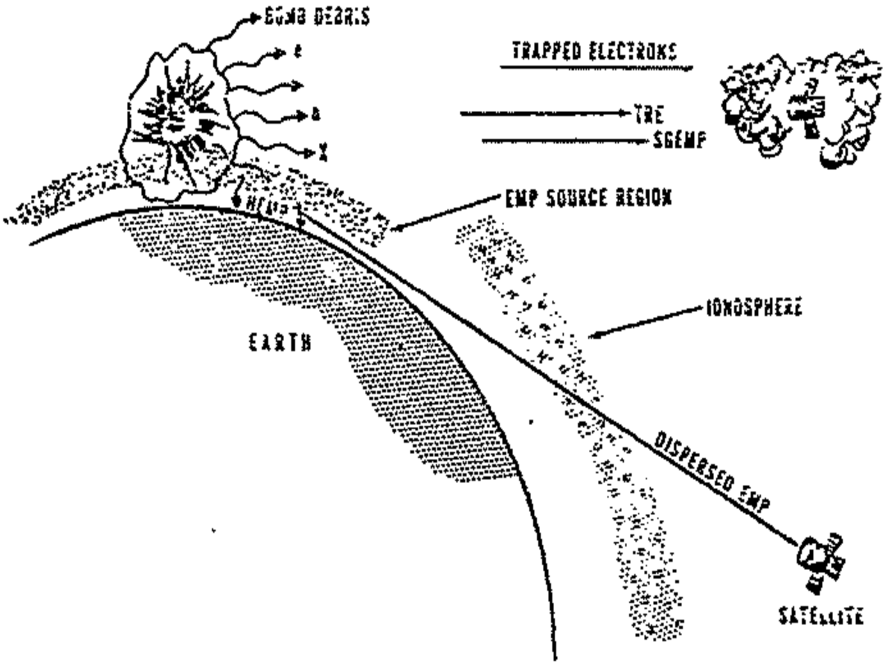


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Figure III-2. Exoatmospheric Burst Environments [redacted]

[redacted] [illegible] The pulse duration [illegible] and is about [illegible] environment is [illegible] energy producing [illegible] MeV silicon damage equivalent.

[redacted] Since neutrons have high [illegible] charge, it is difficult to provide adequate shielding. The principal type of [illegible] resulting from neutron bombardment of [illegible] the material's lattice structure. The [illegible] reduction of minority carrier lifetime in semiconductor devices. Neutrons may also indirectly produce ionization damage to materials. The ionizing doses are usually small compared to the doses due to photon radiation. However, the long duration of the neutron pulse relative to the duration of the photon pulse from a distant nuclear detonation may become significant in components sensitive to neutron ionization.

b. Debris

[redacted] The debris from a nuclear explosion consists of very hot, ionized gases resulting from vaporization of the fissionable materials of the weapon, the weapon casing and other materials that may have been in the vicinity of the explosion. When the detonation occurs at high altitude so that the debris motion is not affected significantly by the atmosphere, a part of the ionized debris will follow geomagnetic field lines while part will move in "jets" across field lines. The containment of debris by the geomagnetic



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field is very effective at burst altitudes of a few hundred kilometers, but much less effective at half synchronous altitudes (11 000 nm) and higher. The magnetic field lines are symmetrical to the geomagnetic equator so that debris injected with velocity components parallel to the field lines moves rapidly in "beta tubes" to the conjugate points, or northern and southern latitudes at which the field lines enter the atmosphere. Most of the debris is lost by interaction with the upper atmosphere at the conjugate points, though small quantities may be reflected at geomagnetic minor points and be briefly trapped. The importance of this debris is in the environments it can produce. Radioactive debris can plate out on the surface of satellites and become local radiation sources. Decaying debris emits Beta and Alpha particles, Gamma radiation and neutrons. This radiation can effect the operation of the various components on the satellites. One example is the production of noise in star sensors which can cause the satellite to lose attitude reference.

[redacted] The debris can also interact with the upper atmosphere to cause electromagnetic radiation emissions in wavelength regions from near ultraviolet through the visible to the near infrared. These emissions can temporarily produce false signals, blind, or even saturate optical detectors on satellites.

c. Argus Effects

[redacted] Another debris produced environment is the formation of artificial radiation belts due to the trapping of the emitted electrons in the geomagnetic field. The Beta decay of fission fragments and the ionization of the warhead material produce large quantities of energetic electrons. When electrons become trapped in the Earth's magnetic field, the resulting phenomenon is known as the Argus effect.

[redacted] When a nuclear detonation occurs in the atmosphere, the vast majority of the ionization electrons are recombined and the Beta decay electrons become attached to the atmosphere and debris atomic species. Thus, electrons as a prime effect may be disregarded for atmospheric, surface, and subsurface bursts.

[redacted] For exoatmospheric nuclear bursts and for bursts sufficiently high in the atmosphere so that the buoyant rise of the fireball and debris reach altitudes of 120 km or more, significant numbers of electrons are injected into regions of extremely low atmospheric density. Being charged particles, the electrons spiral along the earth's magnetic field lines reversing their travel along the lines at places called "mirror"

points. The electrons may oscillate between these conjugate points of the magnetic fields with a bounce period on the order of 1 second and may become trapped for long periods. The wide spread of velocities of electrons and continued injection of new electrons from the Beta decay of debris spread out the electrons into a tube between the conjugate or mirror points. An eastward drift of the tube results from non-uniformities of the magnetic field, which together with the relatively long duration of injection from debris results in smearing out the tube so that it is no longer cylindrical, but rather toroidal shaped. This longitudinal spread takes about 6 hours for the electrons to become evenly distributed around the earth. These trapped electrons escape from the magnetic field either into space or by absorption in the atmosphere in time periods of days, weeks, or months, depending on the fieldlines in which they were initially trapped.

[redacted] The artificial electron belts created by the trapped electrons are superimposed on the natural electron belts and the fluxes are additive. It should be noted, however, that the trapped electron spectrum is more energetic than the natural electron spectrum.

[redacted] Satellites operating in the trapped electron belts, traversing the belts, or being traversed by the initial Beta tubes will experience effects which can temporarily or permanently upset their operation. The high energy electrons incident on the satellite, bombard material nuclei and produce X rays. The X rays can then, in turn, produce transient radiation effects or damage due to total dose. The X rays or more properly, Bremsstrahlung, can reach very high levels internally within fairly well-sheltered component spaces.

d. Blackout

[redacted] Blackout is usually defined as any disturbance of propagated signals which causes intolerable degradation of system performance. Most of these effects, absorption, refraction, clutter, noise, and scintillation, are produced, either directly or indirectly, by the ionization resulting from a nuclear detonation.

[redacted] Absorption, which is probably the most well-known blackout effect, is directly dependent on the altitude and the number of free electrons encountered by a radio or radar beam that travels through the disturbed atmosphere. Generally, absorption decreases with increasing frequency. For systems operating in frequency bands in the 1- to 10- GHz range, the region of significant ray-path absorption is usually confined to the

fireball, however, other important absorption regions may exist, for example, due to beta particle ionization. Because of the relatively small size and rapid motion of fireballs from bursts below 100-km altitude, the duration of fireball absorption for low altitude bursts is limited to the path intersection time typically tens of seconds. For higher altitude bursts, the fireball motion may not be sufficient to move the region out of the line-of-sight to synchronous satellites, and the period of attenuation may be extended to several hundred seconds. Beta particle ionization will produce absorption degradation over a region determined by the fission-debris expansion for tens to hundreds of seconds, depending on frequency, burst altitude, and the fission yield of the detonation.

[redacted] Fireball thermal noise after a nuclear burst can be significant in degrading the performance of satellite communication systems. The amount of electromagnetic thermal radiation reaching the receiver antenna depends on the effective fireball temperature at the frequency of interest (a function of temperature and emissivity) and on the amount of attenuation between the fireball and the antenna. Thermal noise also is a strong function of antenna beamwidth. Noise degradation will generally be associated with significant fireball absorption degradation. For bursts above 100 km, the duration due to thermal noise may even exceed the absorption degradation time, especially at the higher propagation frequencies. Typical degradation times may be several hundred seconds for such environments.

[redacted] Group time delay associated with signal propagation through a plasma is usually frequency dependent. This causes phase distortion of angle-modulated signals resulting in what is termed intermodulation noise. This frequency-dependent time delay, or dispersion, also results in envelope distortion for pulse transmission through a plasma. The physical phenomenon associated with these effects is the formation of striation structure (both within and outside the fireball) associated with irregularities in electron densities above the D region of the ionosphere. The striation structure can be very long-lived, on the order of hours, and widespread, shadowing areas of the earth for tens and hundreds of thousands of square kilometers.

[redacted] In summary, there are several types of propagation degradation that may be expected during a nuclear environment, the relatively short-lived absorption and thermal noise produced by intense ionization in the comparatively localized region of the low altitude, burst fireball, and rather long-lived widespread scintillation and fading caused by the striation structure associated with a high altitude burst. Of these, the

latter has most significance for satellite communication systems and unfortunately is the least understood. The phenomenology of the high altitude detonation, particularly for significant time duration after the detonation, is not well known. The modeling of some of the phenomena such as striations, associated with high altitude bursts, is really just beginning.

e. EMP [redacted]

[redacted] The EMP from a nuclear detonation is a burst of radio frequency energy. The pricipal source of EMP is the prompt gamma radiation that is emitted in a pulse whose duration is about 10 nanoseconds. The gamma rays interact with the atmosphere to produce a current of Compton recoil electrons which are ejected radially away from the point of detonation. The interaction of this large number of electrons with the earth's field gives rise to electro-magnetic radiation. The characteristics of this EM radiation are determined by the density of the surrounding atmosphere, the symmetry of the electron movement, whether there is a ground surface within range of the electrons and the direction of electron flow relative to the earth's magnetic field. The following figure illustrates the Compton process.

[redacted] The EM radiation propagates in the form of a large spike with a very short duration. When this pulse interacts with a system, it will cause currents to run on all metallic conductors external to the system. This not only includes cabling, but also any pipes, antennas, and the housing of the system itself.

[redacted] Whether these transient currents, or even the pulse itself, enter the system depends on the design and construction of the system. However, if they do enter, then large voltage and current transients can exist within the electrical equipment of the system. The significance of these transients depends largely on the type and function of the equipment. Component burnout or state changes in logic elements may occur and result in the failure of the system to perform its mission.

[redacted] The shape and spatial extent of the EMP signal generated by a nuclear detonation depend primarily on gamma output and height-of-burst (HOB). There are three categories of bursts which are important for military systems: Surface, air, and high altitude, and each has its own particular characteristic.

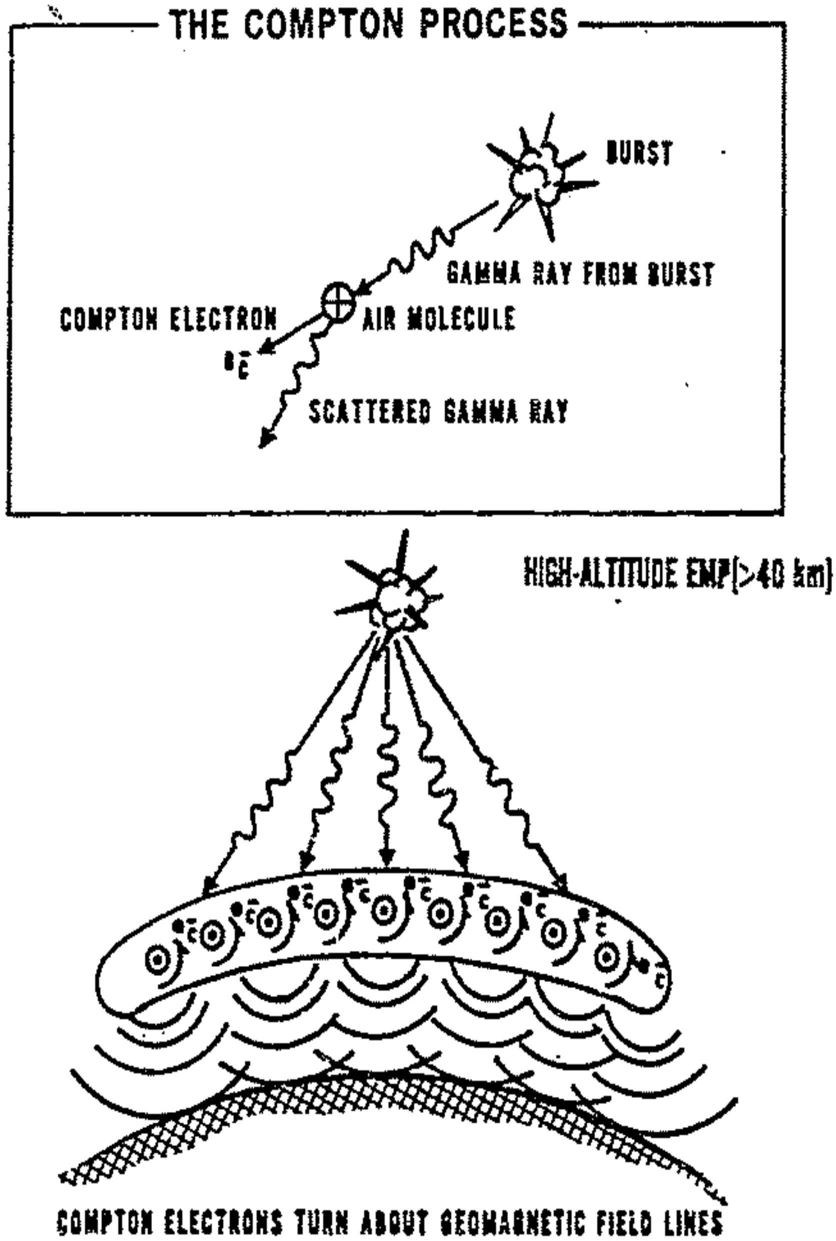


Figure III-3. EMP Generation [redacted]

[redacted] Surface bursts are characterized by the large asymmetry in the distribution of charged particles caused by the presence of the ground. This results in large amplitude radiated EM pulses being generated; however, their spatial extent is limited to the high blast and overpressure regions.

[redacted] Air bursts (2-20 km) results in an electromagnetic configuration which is roughly spherically symmetric. In this approximation, a strong radial electric field is produced, and there is little magnetic field and little radiated field. Actually, deviations from spherical symmetry, such as bomb asymmetries, air density gradient, and the geomagnetic field, do lead to magnetic and radiated fields, but these may be regarded as small.

[redacted] High Altitude EMP (HEMP) is produced by nuclear detonations above approximately 40 km. The prompt gammas emitted by such a burst travel radially outward from the burst point in a spherical shell on the order of 10-meters thick. When the downward going part of the shell reaches the atmosphere between about 40-km and 20-km altitude, these gamma rays are absorbed in the deposition region. The resulting Compton electrons are deflected by the geomagnetic field, forming a transverse current pulse. The front of this current pulse moves nearly as fast as the gamma shell, at the velocity of light. Therefore, the current pulse keeps in phase with the outgoing electromagnetic wave it generates, and this is the reason for the remarkable efficiency of the HEMP mechanism.

[redacted] The HEMP effect takes on increased importance when one considers that a single weapon, detonated a few hundred kilometers above the earth, can blanket the entire CONUS with an electromagnetic signal of tens of thousands volts/meter. This EMP can also exist for surface and air bursts but its magnitude and range are considerably smaller when balanced to nominal blast and overpressure values.

[redacted] Dispersed Electromagnetic Pulse (DEMP) is a by-product of the high altitude EMP resulting from endoatmospheric and exoatmospheric nuclear detonations. When the high altitude EMP is propagated from the burst point through the ionosphere to a satellite, its characteristics are modified by dispersion, absorption, and refraction effects. These effects result in the cutoff of the lower frequency of the pulse spectrum and the time sorting or dispersion of the rest of the frequency spectrum, hence, the name dispersed EMP.

f. SGEMP [redacted]

[redacted] Ionizing photon radiation from a nuclear detonation will interact with the materials of a satellite to produce SGEMP. Electrons are ejected from exterior surfaces of the satellite due to low energy X-radiation interactions through the photoelectric effect. The high energy X- and gamma radiation penetrates, or "shines through" to the interior structure and equipment to eject additional electrons by the Compton scattering process, enhancing the electron's emissions due to photoelectric effects. These interactions create clouds of free electrons on the outside as well as on the inside of the satellite. These emitted electrons cause electric and magnetic fields which can couple electrical energy into sensors, antennas, and cables entering electronic subsystems on the satellite and, as a result may cause a system malfunction. The direct interaction of radiation with cables can also cause electrical energy to be coupled into electronic subsystems.

[redacted] The effects of SGEMP are dependent upon a number of parameters including system geometry, system materials, radiation intensity and spectra, and radiation pulse width and rise time. Solution of problems caused by SGEMP is difficult because of the complex physical phenomena involved and the extensive computations required to predict the system response. However, an extensive amount of work is being conducted to devise better analysis and modeling techniques. Full system X-ray simulation techniques are also being investigated. The currently ongoing efforts are expected to reduce the uncertainties associated with SGEMP on satellites to workable levels within the near future. Most military satellites employ RF shielded cables and when this is done the controlling SGEMP effect is that from direct X-ray interaction with the cables. For that interaction, cables are tested in a Dense Plasma X-ray Facility and therefore, good accuracy is obtained and the dependence on computation minimized.

# GLOSSARY

| | |
|---|---|
| ABM | Anti-ballistic missile |
| ABM X-3 | Advanced GALOSH |
| A/D | Analog-to-digital |
| A/G | Air-to-ground |
| AGI | Soviet intelligence ship |
| ALCOR | ARPA/Lincoln Labs Correlation Radar |
| ARM | Anti-radiation missile |
| AFSCF | Air Force Satellite Control Facility |
| ASAT | Anti satellite |
| BMEW | Ballistic Missile Early Warning |
| C&T | Communications and tracking |
| C&W | Caution and warning |
| CFA | Cross Field Amplifier |
| CIS | Communications Interface System |
| CO | Carbon Monoxide |
| CO2 | Carbon Dioxide |
| COMINT | Communications Intelligence |
| COMSAT | Communications Satellite |
| CW | Continous Wave |
| DOD | Department of Defense |
| D/A | Digital-to-Analog |
| DB | Decibel |
| DBW | Decibel above one watt |
| DCC | Data Computation Complex |
| DCS | Display & Control System |
| DEMP | Dispersed Electromagnetic Pulse |
| DMSP | Defense Meteorological Satellite Program |
| DSARC | Defense Systems Acquisition Review Council |
| DSCS | Defense Satellite Communication System |
| DSP | Defense Support Program |
| ECM | Electronic Counter Measures |
| EDL | Electric Discharge Laser |
| ELINT | Electronic Intelligence |
| EMP | Electromagnetic Pulse |
| ERP | Effective Radiated Power |
| EW | Electronic Warfare |
| Far Term | To the year 2000 |
| FLTSATCOM | Fleet Satellite Communications |
| FM | Frequency Modulation |
| FSK | Frequency Shift Keying |

| | |
|---|---|
| GHz | Gigahertz |
| GPS | Global Positioning System |
| HEL | High Energy Laser |
| HF | High Frequency or Hydrogen Fluoride (Laser) |
| HOB | Height of Burst |
| HUMINT | Human Intelligence |
| ICBM | Intercontinental Ballistic Missile |
| IOC | Initial Operational Capability |
| ICD | Imitative Communications Deception |
| Interference | Active means that physically influences the performance of the target satellite. (Overt - The interfering party expects the agency and method to be known to the party interfered with.) (Covert - The interfering party expects to conceal the agency and/or method from the party being interfered with.) |
| Isp | Specific Impulse |
| IR | Infrared |
| ITU | International Telecommunications Union |
| IUS | Interim Upper Stage |
| JSC | Johnson Space Center |
| Ku(-band) | Designator for frequency band from 12.4 to 18 GHz |
| KSA | K-Band Single Access |
| KSC | Kennedy Space Center |
| LCC | Launch Control Center |
| LOC | Lines of Communication |
| LWIR | Long Wave Infrafed |
| Mb/s | Megabits per second |
| MCC | Mission Control Center |
| MHz | Megahertz |
| MOS | Mission Operations Systems |
| NASA | National Aeronautics and Space Administration |
| NASCOM | NASA Communications Network |
| Near Term | To the year 1985 |
| OTH | Over-the-horizon (radar) |
| P/L | Payload |
| PCM | Pulse Code Modulation |
| PCR | Payload Changeout Room |
| PM | Phase Modulation |
| POCC | Payload Operations Control Center |
| PPF | Payload Processing Facility |
| PPR | Payload Processing Room |

| | |
|---|---|
| Probing | Delibarate action taken to affect the target satellite or mission data but does not significantly degrade either. Conducted primarly to learn about satellite system operation and to test counter measures techniques. |
| PSK | Phase Shift Keyed |
| PTF | Payload Test Facility |
| QPSK | Quadriphase Shift Keying |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| ROK | Republic of Korea |
| RV | Reentry Vehicle |
| RVCF | Remote Vehicle Checkout Facility |
| S-band | Designator for frequency band between 1.55 and 5.2 GHz |
| SAMSO | Space and Missiles Systems Organization |
| SCF | (Air Force) Satellite Control Facility |
| SCR | Stripchart Recorder |
| SEP | Spherical Error Probable |
| SDS | Satellite Data Systems |
| SIGINT | Signals Intelligence |
| SLBM | Sea-launched Ballastic Missile |
| SNR | Signal-to-noise ratio |
| SOI | Space object identification |
| SSV | Space Shuttle Vehicle |
| STC | (Air Force) Satellite Test Center, Sunnyvale, CA |
| STDN | Spaceflight Tracking and Data Network |
| STS | Space Transportation System |
| TACAN | Tactical Air Navigation |
| TBD | To be determined |
| TDRS | Tracking and Data Relay Satellite(s) |
| TDRSS | Tracking and Data Relay Satellite System |
| TEMPEST | Unclassified short name (not an acronym) |
| TREE | Transcent Radiation Effects on Electronics |
| TWT | Traveling Wave Table |
| VAFB | Vandenberg Air Force Base |
| VTS | Vandenberg Tracking Station |
| ZOE | Zone of Exclusion |

Metric Conversion Table

(U) By direction from the Defense Intelligence Agency, beginning 1 January 1976 all intelligence reporting of parameters and measurements is required to be in consonance with internationally accepted standards. The directed standard is the International System of Units (Systeme International d'Unites) (SI), or, as it is commonly referred to, the metric system. For the benefit of users who require values expressed in customary units, metric units applicable to this document are listed below along with the corresponding value in customary units.

| Quantity | Metric Unit | Symbol | Multiply By | To Get |
|---|---|---|---|---|
| Range, apogee | kilometer | km | 0.5399568 | nmi |
| Length | meter | m | 3.280840 | ft |
| Weight (mass) | kilogram | kg | 2.204623 | lb-mass |
| Thrust | kilonewton | kN | 224.8089 | lb-force |
| Specific Impulse | newton-second/ kilogram | N s/kg | 0.1019716 | "second" |
| Overpressure | megapascal | MPa | 145.0377 | psi |
| X-ray fluence | joule/square meter | $J/m^2$ | $0.239005 \times 10^{-4}$ | $cal/cm^2$ |
| X-ray dosage | joule/kilogram | J/kg | 100 | rad |
| Energy | joule | J | $0.6241457 \times 10^{19}$ | ev |
| Velocity | meter/second | m/s | 3.280840 | ft/sec |
| Wavelength | micrometer | μm | $10^4$ | angstrom |



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| DIA | |
| DT-4C | 3 |
| DB-1F3 | 1 |
| DE | 1 |
| DCA/MSO | 1 |
| NSA/S11 | 20 |
| Hq NASA/MO | 5 |
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| DRA | 1 |
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| DOK | 1 |
| XPQ | 1 |
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| DOO | 1 |
| DCX | 1 |
| HQ RADC/IN | |
| AFWL | |
| IN | 1 |
| NTN | 5 |
| ESD | |
| IN | 1 |
| XRB | 1 |
| HQ AFOSI/IVO | 1 |
| FTD | |
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| SDS | 1 |
| TQF | 1 |
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| AWS/DYC | 1 |
| AFALD/SDM | 1 |
| HQ AFLC/LOW | 1 |
| 63 MAW/IN | 1 |
| 6550 ASTW/IN | 1 |
| 6595 ASTW/IN | 1 |
| AFAL/RWA-666A | 1 |
| HQ USAFSS | |
| DOKOS | 2 |
| XOGOS | 1 |
| HQ SAMSO | |
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| LVX | 2 |
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| SKF | 1 |
| SKD | 1 |
| SACSO | 1 |
| SKX | 1 |

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| IN | | 100 |
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